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## Compartments of the Arcuate Fasciculus Visualized with High Angular Resolution Diffusion Imaging

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### Introduction

The arcuate fasciculus (AF) of the left cerebral hemisphere is best known as the key fiber tract connecting Wernicke's and Broca's areas, thus making it a critical pathway for the processing of speech and language. The recent application of diffusion imaging to study fiber tract anatomy allows for further investigation of this pathway and its other potential temporo-frontal termination points.

We describe the use of streamline tractography using high angular resolution diffusion imaging (HARDI) data from neurologically-normal individuals to investigate the anatomy of the AF. Specifically, we asked: Which anatomically-unique temporo-frontal AF compartments can be elicited with HARDI tractography? Which cortical areas appear connected by these compartments? What is the relationship of the AF to other brain regions also implicated in language?

### Methods

AF fibers were isolated using streamline tractography applied to HARDI data from seven neurologically-normal participants (Siemens Verio 3T MRI scanner, 64 gradient directions, three repetitions,  $b = 2000 \text{ s/mm}^2$ ,  $2 \text{ mm}^3$  voxels, GRAPPA factor = 2). While standard diffusion tensor imaging (DTI) can estimate only the dominant fiber orientation at each voxel, HARDI can resolve multiple orientations within the same voxel, permitting a much richer visualization of white matter anatomy. Streamline tractograms were derived using MRTrx software with the constrained spherical deconvolution technique and visualized with TrackVis. The core sections of the AF were segmented using regions of interest capturing both the vertical ascending fibers of the temporal lobe and those traversing in the horizontal plane after arching over the posterior insula. High-resolution T1-weighted structural images were used to assess the relationship between fiber trajectories and gyral anatomy, and to delineate different branches of the AF based on their cortical terminations.

### Results

Reconstruction of the AF with this technique revealed a rich bundle of fibers with extensions between the middle and superior temporal lobes and numerous gyri within the frontal lobes and insula (Figure 1). Averaging of the data revealed three temporal-frontal compartments terminating in Brodmann's Area 44, the Rolandic operculum, and the precentral gyrus of the insula. The BA 44 and insular compartments terminated in both the superior temporal (STG) and middle temporal (MTG) gyri, while the Rolandic compartment terminated in the MTG. AF fibers terminating in

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the MTG were far more prevalent than those terminating in the STG, including those traversing to BA 44.

### Conclusions

While DTI approaches the detail offered by anatomical studies, HARDI allows for even better characterization of the rich distribution of fiber pathways. With it, we could explore the AF branches that project into the insula and MTG and calculate the number and density of fiber streamlines connecting the different frontal and temporal regions. These findings suggest that the AF may support a far more extensive speech and language network than previously thought, where a better understanding of its multiple compartments and numerous terminations could help improve classical models.

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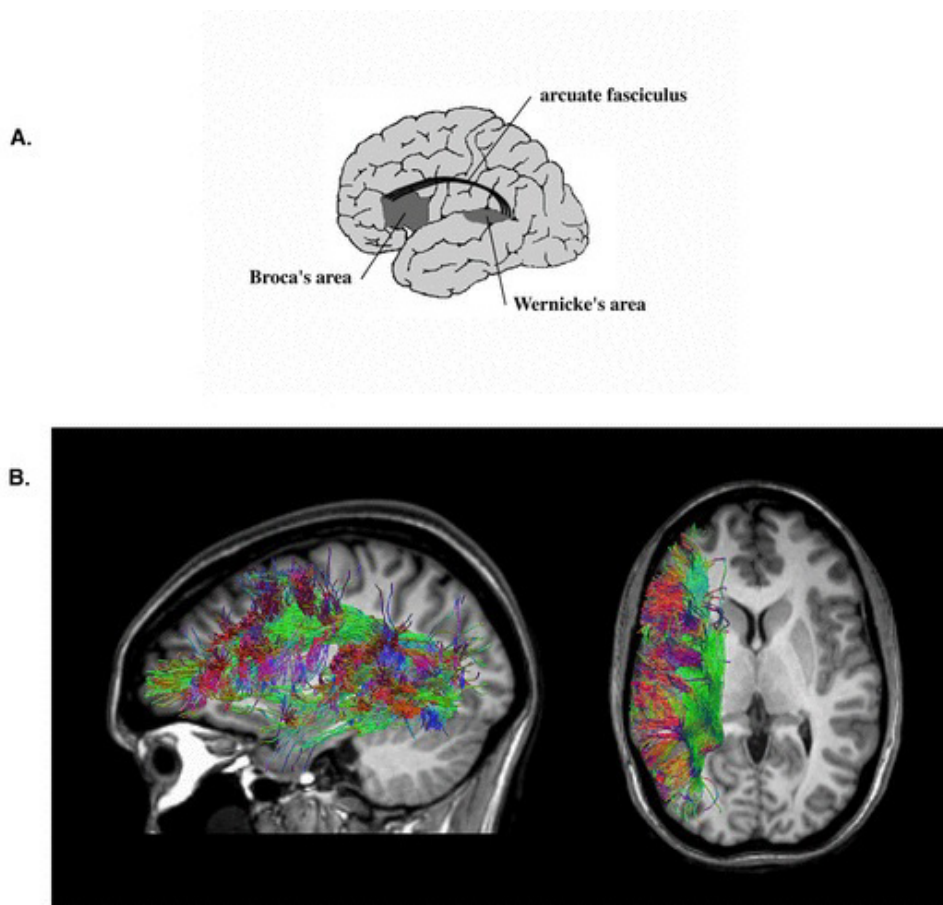


Figure 1. A. Simplified classic model of the arcuate fasciculus connecting Wernicke's and Broca's areas. B. More realistic complexity of the arcuate fasciculus as revealed by high angular resolution diffusion imaging.